The Interpretation of the Manifestations of Shock

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Reprinted from the Pennsylvania Medical Journal
December, 1918, Vol. XXII, p. 123

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INTRODUCTION

In studying shock in the laboratory, the first consideration has been to try to discover the causative mechanism or mechanisms, with the view of establishing scientific interpretations of the phenomena and with the ultimate purpose of developing rational methods of prevention and treatment.

Studies have been limited to experiments with laboratory animals, mainly dogs. Thus, at the outset, such investigations are handicapped by the uncertainty that the conditions induced are identical with the conditions in man, as well as the difficulty of diagnosis. Consideration of the biologic differences in animals and man, especially psychic development, the great variation in the susceptibility of individuals, and the differences in the experimental conditions and the conditions under which shock is exhibited in such experiments and in man, as anesthesia in the former and its absence in the latter, renders the above view obvious. Even surgical shock in man rarely is strictly comparable to experimental shock, for usually surgical procedure is undertaken to correct abnormality,

* Read at the General Meeting of the Medical Society of the State of Pennsylvania, Philadelphia Session, Sept. 24, 1918.

while, as a rule, animals employed in experimental studies are normal.

The very great resistance of many animals to shock induction led investigators to employ methods of extreme character and magnitude, so that search for causative mechanisms has been complicated and obscured. By such treatment, any animal may be reduced to a lethargic condition before death, but assumption that such condition fundamentally corresponds to typical shock in man is unwarranted.

In a series of forty-four animals studied, in a few cases only, has a close likeness to typical shock in man been observed. In other work in which dogs were operated on surgically, in a few instances, conditions that closely resembled "surgical" shock in man occurred.

Therefore, the difficulties encountered in shock induction and diagnosis, though perhaps not insuperable, are very great and account largely for the meager results of value in clearing up the question.

RESULTS

Our studies so far in the search for causative mechanisms have been for the most part negative. For example, studies of the blood for significant change in volume, and in morphologic and chemical composition, have been negative; or changes of possible significant quality or degree have been negatived by control observations.[1] Circulatory, respiratory and thermal changes for the most part have been of similar character, that is, not primarily causa-

1. Guthrie, C. C.: Amer. Jour. of Phys., 1918, xlv, 544; Arch. of Int. Med., 1918, xxii, 1.

tive of shock. The evidence points rather to the central nervous system as the probable seat of primary change, particularly to the bulbar mechanisms presiding over circulation and respiration. At present our data exhibits gaps, owing to the lack of adequate methods for measuring the functional state of such tissues. But the facts obtained, when considered from the standpoints of analogy and clinical observation, we believe, warrant this view.

We have observed alterations in nervous activities, particularly of bulbar centers.[2] Though presenting marked variations, results obtained in pronounced shock showed that both reflex vasomotor and respiratory response may be profoundly decreased. Decrease in reflex augmentation of arterial blood pressure occurred, both actual and in percentage of blood pressure. That the result in some instances was not due to stimulation fatigue was shown by stimulating more centrally along the nerve trunk, and by moderate mechanical nerve stimulation, as rhythmic traction. That it was not due to fatigue of a single path due to repeated stimulation (synaptic fatigue), or to possible localized central fatigue, was shown by stimulating a nerve connected with a remote spinal segment.

Before drawing conclusions from such observations, it is necessary to know whether or not reflex vasomotor augmentation is a true index of the state of activity and capacity of the vasomotor mechanism. If it be assumed that when the vasomotor mechanism is in good

2. Presented in part before the Biological Society of the University of Pittsburgh, Nov. 1, 1917, and the Amer. Phys. Soc., Minneapolis, Dec. 27, 1917.

functional state that its activity is, say, 60 per cent. of what it is capable of manifesting, and that in another state it exhibits 90 per cent. of its capability, and that in both cases its total capabilities, or 100 per cent., can be elicited reflexly, it seems permissible to conclude that reflex response may serve as an index of degree of "tonic" functional activity, i. e., "tonic" activity would vary *indirectly* as reflex augmentation. But results have shown that with a high pressure level associated with increased vasomotor activity, reflex augmentation may be greater than at lower pressure levels and under more normal conditions. Also, we have occasionally observed reflex depression only before, and augmentation only after shock. These results do not disprove the possibility of the correctness of the view as to the relation of reflex response to functional activity, but illustrate the impossibility of drawing definite conclusions from such observations owing to inability to control the factors which govern response, such as possible change in reflex threshold, "treppe" effects, or other conditions as "reversal" phenomena.

Disappearance of reflex vasomotor depressor effect before vasomotor augmentation has been observed, which may lead to erroneous conclusions as to the state of the vasomotor center, when conclusions are based on augmentation of blood pressure alone. This appears to be in line with the observation that in resuscitation, stimulation of the depressor nerve may give augmentation and no depression.[3] As illustrative of

3. Stewart, G. N.: Manual of Physiology, 1914, p. 185.

this, we have observed reflex depression with absence of augmentation in an animal in good condition, while later, and after prolonged nerve stimulation and partial cerebral anemia (and even after death and resuscitation, procedures which certainly, on the whole, tend to lessen reflex capabilities), we were able to obtain reflex vasomotor augmentation only. We would interpret this result as due, not to an increase in vasomotor augmentor activity, or reflex capability, but as more probably due to some other condition, as unmasking of augmentation by decline or disappearance of depressor action.

In the case of the respiratory center also, under certain conditions tonic activity may vary indirectly as reflex response. For example, after movements have ceased, as in suffocation, they may be elicited by nerve stimulation.

INDIRECT EVIDENCE

Indirect confirming evidence of fatigue of the vasomotor mechanism is furnished by comparing the results of restorative measures in profound shock and in animals rapidly devitalized or reduced to a latent state as by ether, suffocation, injection of acid or profound cerebral anemia. Even after repeated resuscitation, we have obtained prompt recovery, it being necessary to readminister anesthetic; while in profound shock, recovery to like degree is rare and always gradual. In this respect it is more nearly like resuscitation after longer periods of inanition, or resuscitation after respiratory

and circulatory failure from prolonged deficient cerebral circulation.

Comparison of vasomotor and respiratory effects in conditions of acute profound cerebral anemia and in prolonged partial cerebral anemia associated with nerve stimulation, and in shock induced by prolonged nerve stimulation only, gives additional evidence of fatigue of the vasomotor mechanism. Though presenting variations, we have observed comparatively abrupt termination of respiratory and vasomotor activity in acute profound cerebral anemia. Respiratory activity seems prone to disappear before vasomotor activity; and in resuscitation, both activities to reappear in the reverse order. In prolonged partial anemia, a condition very similar to shock supervenes, and respiratory and vasomotor activities more slowly decline, and in resuscitation more slowly reappear. Respiration usually is more persistent, and is first restored. Further study of such phenomena is essential.

These results indicate that cessation of function without great exhaustion occurs in the acute condition; while fatigue, from increased activity due to anemia and to nerve stimulation leads to greater exhaustion. This view is in harmony with the results of studies which have shown that extensive chromatolysis occurs in the nerve cells of the central nervous system under conditions of increased activity and of cerebral anemia, and in shock.[4]

The failure in profound shock of drugs act-

4. Gomez, L., and Pike, F. H.: Jour. of Exper. Med., 1919, xi, 257. Dolley, D. H.: Jour. of Med. Research, 1908, xx, 275; 1910, xxii, 331; 1913, xxix, 65.

ing on the central vasomotor mechanism is further evidence of fatigue.

Such results have strengthened the view that probably derangement of the nervous tissues is a causative factor in shock.[5] Certainly in these experiments it has been a prognostic consideration of first magnitude. Its close relation to the later or profound stages of shock (i. e., collapse) is more apparent and it is especially these stages that are of such practical consideration at present. In earlier stages of induction of shock associated with definite symptoms, we have observed a strong tendency to recover on discontinuing the procedures employed to induce the condition.

CLASSIFICATION AND TREATMENT

The classification of shock previously proposed we still consider logical and practical.[6] Accordingly we are inclined to believe that shock of sudden onset in normal individuals, whether of psychic, traumatic, or psychotraumatic type, preponderatingly is of inhibitory character, which is in agreement with a view expressed by Meltzer.[7] Such shock may be of all grades of severity, and in many instances spontaneous recovery occurs, and in more severe types recovery may be brought about by application of stimulating therapeutic measures. Such recovery in itself is evidence that inhibition rather than exhaustion is present. This

5. Guthrie, C. C.: Jour. of the Amer. Med. Assn., 1917, lxix, 1394.
6. Guthrie, C. C.: Blood Vessel Surgery and Its Applications, p. 344, 345; Jour. of the Amer. Med. Assn., 1917, lxix, 1394.
7. Meltzer, S. J.: Arch. of Int. Med., 1908, i, 571.

view is further substantiated by the fact that exhaustion is always preceded by fatigue and fatigue is a gradual process.[8]

In individuals in poor condition, that is, when the tissue functional capacities are low, or, in other words, when the reserve capacity of the "vital" centers is depleted and they are functionating near maximum, which quantitatively may be but little above minimal requirements, shock is more readily induced and more rapidly becomes profound and passes into collapse. From this viewpoint it is obvious that prompt treatment is demanded to prevent the condition passing into collapse. In collapse the picture is one of exhaustion and, therefore, treatment indicated differs entirely from that in shock. The tissues are functionating maximally, but their capacity is below minimal requirements; the problem, therefore, is to build up tissue capacity. The logical way to bring this about is to improve the quality and increase the quantity of blood circulating through the "vital" centers and other tissues in so far as is possible; and to maintain minimal demands on their activities. Lowering of the head, abundance of fresh air or administration of oxygen, application of heat, and the giving of warm drinks, are logical and commendable practices.

In case of serious hemorrhage, blood transfusion is indicated, and should be performed without delay. Common salt solution, if injected promptly, may be of value to compensate in volume temporarily for extensive blood loss.

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8. Porter, W. T.: Amer. Jour. of Phys., 1908, xx, 405.

Viscous substances added to salt solutions for such injections may cause longer retention of the liquid in the blood vessels.[9] In the case of acacia, recommended by Bayliss,[10] one mechanism of its retention seems to be its action in suppressing urinary secretion. But I am not aware that it has been shown that the nutritive quality of the blood is improved by its presence, and, since under the low arterial blood pressure levels present in such conditions urinary secretion is profoundly decreased, it is not altogether clear that the addition of such substance is advantageous, unqualifiedly. For plain salt solution may promptly restore an acutely failing circulation due to deficient blood volume, unless blood loss has been excessive. In view, however, of current clinical experience, it would be conservative practice to add a colloidal substance to solutions used for such purpose.[11] (Six per cent. acacia in 0.9 per cent. NaCl has been recommended by the British.)

Others, notably the Russians,[12] have used hypertonic solutions, as salt, on the theory that such solutions will rapidly attract liquid from the tissues into the blood and thus increase the blood volume and restore the circulation. Such solutions are among, if they do not constitute, the most powerful diuretic agents, and even with comparatively low blood pressures cause

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9. Bogert, L. J., Underhill, F. P., and Mendel, L.: Amer. Jour. of Phys., 1916, xli, 189.
10. Bayliss, W. H.: Arch. med. belge., 1917, lxx, 793.
11. Rous, Peyton: Jour. of the Amer. Med. Assn., 1918, lxx, 219.
12. Kruglevsky, N. A., Russkiy Vrach, Petrograd, 1917, No. 48; abstracted in Jour. of the Amer. Med. Assn., 1918, lxx, 1576.

rapid urinary secretion. If injected very slowly, such actions as they possess are correspondingly lessened. But all indications point to rapid treatment in shock and collapse.

In dogs with very low blood pressure and failing circulation following hemorrhage, we have obtained excellent circulatory restoration promptly by rapid injection of strong cane sugar solution (34.2 per cent.) notwithstanding the rapid excretion by the kidneys as soon as the blood pressure had risen to the level necessary for renal activity. In view of these results as well as favorable results hitherto obtained in preserving the vitality of isolated tissue in cane sugar solutions, and by Rous[13] with cane sugar solutions in preserving the vitality of red blood corpuscles in *vitro*, we feel warranted in concluding that by comparison, cane sugar is a desirable substance to choose for further experimental study.

GENERAL SUMMARY

It is recommended that the term shock be reserved for the condition exemplified by the acute clinical state; and that the term collapse be employed to designate the moribund state following shock or any other condition.

Experimental evidence is presented supporting the probability that the primary derangement in shock is of nervous character.

In collapse, indirect and general considerations strongly indicate profound nervous derangement.

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13. Rous, Peyton, and Turner, J. R.: Jour. of Exper. Med., 1916, xxiii, 219.

The conditions in shock and collapse differ fundamentally and treatment indications differ accordingly.

In shock, associated with severe hemorrhage, restoration of blood volume is indicated. For this purpose transfusion seems best, but beneficial action may be obtained by intravenous injections of artificial solutions. The addition of a colloidal substance to such solutions causes their longer retention. For this purpose dilute acacia seems preferable to other substances hitherto employed.

Preventive measures and prompt treatment are strongly indicated.

Preventive measures are worthy of the most serious consideration, but they have been omitted from this discussion as we lack adequate first-hand observations. Discussion of theories is omitted for the reason that at the present time they are legion and no one has overwhelming support.

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